MINISTRY OF TRANSPORT

RAILWAY ACCIDENT

Report on a Diesel multiple unit train that caught fire on 10th October 1964 between Millbrook and Wilshamstead

IN THE

LONDON MIDLAND REGION

BRITISH RAILWAYS

LONDON: HER MAJESTY'S STATIONERY OFFICE
1965

ONE SHILLING NET

MINISTRY OF TRANSPORT,
ST. CHRISTOPHER HOUSE,
SOUTHWARK STREET,
LONDON, S.E.1.

26th February 1965.

SIR,

I have the honour to report for the information of the Minister of Transport, in accordance with the Order dated 15th October 1964, the result of my Inquiry into an accident to a diesel multiple-unit train that happened at approximately 1.43 p.m. on 10th October 1964 at Wilshamstead near Bedford in the London Midland Region, British Railways.

In dull weather the 12.35 p.m. Down eight-car diesel multiple unit passenger train from London (St. Pancras) to Bedford (Midland Road) was travelling at about 60 m.p.h. on the Down Fast line between Millbrook and Wilshamstead signalboxes when fire broke out under the last coach. The driver stopped the train just beyond Wilshamstead box at 1.45 p.m. but before this happened some of the passengers, alarmed by the smoke, heat and roar of the fire, jumped from the train. I regret to state that one, an Italian, was fatally injured when she fell; three others were bruised, and one who jumped after the train had stopped broke her ankle.

The emergency services were called at approximately 1.48 p.m. and the fire brigade arrived at the site four minutes later; in the meantime the driver and guard had checked the fire, which was confined to the underside of the coach. The flames were quickly extinguished by the brigade. Ambulances arrived at 2 p.m.

The rear vehicle was detached from the train which left for Bedford at 2.36 p.m., and the rear vehicle was taken to Bedford Motive Power Depot an hour later.

The fire began after the cardan shaft drive from the forward of the two motors under the rear coach had broken and the flailing ends had punctured the fuel tank. The spilt fuel then caught fire, probably after vaporising on the hot exhaust pipe and being ignited by sparks caused by the flailing shaft.

DESCRIPTION

The Site

1. The four-track route running northwards from London to Bedford, 50 miles away, has the fast lines to the West and the slow to the East. Between Millbrook signalbox, 43¾ miles from London, and Wilshamstead, about 46½ miles, the gradient is generally falling in the Down direction towards Bedford at 1 in 200, with a short level length near Houghton Conquest signalbox half a mile before Wilshamstead is reached. Beyond Wilshamstead the gradient eases to 1 in 300 falling. Curvature is slight and the line is for the most part on a low to moderate bank. Most of the signals are semaphores but there are some colour light distants.

The Train

2. The eight-car diesel multiple-unit train was 179 yards long and weighed 278 tons. It was equipped with the quick release vacuum brake. The train comprised two sets of four vehicles, each set consisting of a power car at each end with two unmotored cars in between. The power cars, of which there are 60 in the fleet for the St. Pancras/Bedford service, had been built at Derby Works in 1959. This design, like that of most multiple-unit sets, has the engines and transmission under the frame so that the whole of the space above is available for passenger or service use. The driving cab is at the outer end of the car, with the guard and luggage compartment at the inner end. There are two passenger compartments, the one next to the driving cab containing 46 seats and with 4 doors on either side and the other 32 seats with 3 doors on either side. There is a solid partition between the two compartments and between the smaller one and the guard's compartment. A narrow sliding door leads from the larger one to the driver's cab, which also has an exterior door on either side. One of the two unmotored cars in each set is of the open type with lavatories and the other is divided into three compartments.

3. Each power car is equipped with two 238 b.h.p. Rolls Royce eight-cylinder engines suspended under the frame near the centre of the car; each engine drives the inner axle of the adjacent bogie through a torque converter, cardan shaft, and, on the axle, a final drive in which is incorporated the reversing meehanism. The auxiliary drive connections for the exhauster, air compressors and fans are made at the opposite end of the engine.

4. The torque converter takes up the "drive" as the engine is accelerated towards its rated speed and it is designed to start the vehicle and accelerate it to the speed at which torque ratio becomes unity, at about 41 m.p.h., when direct drive is engaged through an oil-operated clutch. A free wheel within the converter allows the turbine element to remain stationary while direct drive is engaged, thus avoiding power loss and heating of the converter fluid.

5. The cardan shaft between the torque converter and the final drive is a Hardy Spicer type 1800, 7 ft. 8 ins. long with a universal coupling at each end. It weighs nearly 1 cwt. The main tube of the shaft is of mild steel, 4 ins. in diameter, with a wall thickness of .12 ins. As the length of the shaft must increase when the driven axle of the bogie shifts position on curves the torque converter end of the shaft is fitted with a splined end designed to permit an extension or reduction in length of the shaft of 1½ ins. from the mean.

6. The engine and transmission under the car at the end towards the driver's cab is known as No. 1, the other being No. 2. Each engine and transmission is offset from the longitudinal centre line to the left when looking from the middle of the car towards the end and each fuel tank is on the right opposite the respective cardan shaft. Graviner automatic fire extinguisher equipment is provided over each engine and torque converter but the area it protects does not extend to the fuel tank. It is brought into effect by any of three means. First there is the graviner pipe close to the engine with an explosive fuse wound spirally round it which, by overheating, will set off the extinguisher. Secondly there is a thermostat over the converter which sets off the equipment when it reaches a certain heat, and thirdly there is a manual switch below the frame near the driver's steps. A warning bell rings in every cab and brake van of the train when an extinguisher is set off and a red light shows on the side of the coach where the equipment has worked.

The Course of the Accident and Damage

7. The train stopped with the rear coach, which was on fire, 165 yards ahead of Wilshamstead signalbox. As already stated the source of the fire was fuel oil from the ruptured tanks and apparently the fire lessened in intensity as the train stopped, due to the fuel tanks having been more or less emptied by that time and also perhaps to the reduction in oxygen to feed the flames when the train was no longer moving. Fire extinguishers were brought to bear on it quickly by the train crew and by a railwayman travelling as a passenger and it was under control in a few minutes. The fire had not penetrated inside the car which showed no signs of scorching, but it had licked round and up the sides and round the driver's cab end where, judging from the external scorching, the heat had been intense. The end windows of the cab had been severely heated so that they disintegrated when a little pressure was applied to them. The graviner fire system over the engines had worked correctly.

8. No. 2 cardan shaft under the car (leading to the bogie under the guard and luggage compartment) had broken completely approximately 2 ft. from the torque converter end. The shorter end had then been wrenched from the torque converter and was found on the track, still attached to the converter output flange, some 960 yards before where the rear car stopped. The free wheel housing at the end of the converter had broken and there were signs that the free wheel had jammed. The converter itself had partially broken away from the engine at the connecting flange where a number of bolts had sheared and others twisted. Both fuel tanks were pierced, No. 2 with two gashes on the side, obviously caused by the two flailing ends of the cardan shaft after it broke, and No. 1 underneath presumably by the shorter end of the shaft after it had fallen towards the track and had been prized off the converter when the broken end dug into a sleeper (a sleeper had been badly scored close to where the shaft was found). The shaft may well have bounced up again after this happened to pierce the tank, and the damage to the underside of No. 1 tank was consistent with such a chain of events.

9. The first piece of train equipment found on the track was a small section of the torque converter flange ring (the packing between the converter flange and the engine casing flange) found near Houghton Conquest signalbox, which was closed at the time of the accident, some 220 yards before where the broken shaft was found. There was evidence of fuel oil on the track from where the section of ring was found for about 155 yards, and from this point to where the train stopped the sleepers were charred. The damaged sleeper and the portion of broken shaft were thus about 65 yards past the beginning of the charring. It was some 350 yards ahead of this point close to a small underline bridge that the body of the unfortunate passenger was found.

10. The sequence of events was probably as follows. The cardan shaft broke when the train was at the point where the portion of the flange ring was found, since the breakage of the ring is an indication of very severe stresses having been caused in the transmission. The flailing ends of the shaft then punctured No. 2 tank shorty before the free wheel housing jammed and the short end of the shaft dropped down to dig into the sleeper and be wrenched off at its converter end. In the meantime the spilling fuel had become ignited, due probably to a combination of vaporisation on the hot exhaust pipe and sparks from the flailing cardan shaft. When No. 1 tank was punctured the flames had already caught hold and the additional fuel no doubt added to them. The floor and sides of the coach must have resisted the heat very well, since there was no sign of internal charring, but no doubt the smoke and flame and roar of the fire was very frightening. Also of course some of the windows were open and smoke filled the compartment to add to the confusion of the occupants.

Summary of Evidence

11. *Running Foreman T. Shepherd* who was travelling in the rear car to take duty at Bedford, said that he was sitting near the rear end on the near side. There were other passengers in the compartment including an Italian family at the forward end of it. As the train passed Houghton Conquest box there was a flash of flame outside and then a blaze on both sides, which licked into the compartment through the open windows, accompanied by heavy smoke. He jumped from his side of the car where the flames seemed most intense to the other, then tried to get into the driver's cab to apply the brake in it; failing this he pulled the communication cord on the off side, with no effect apparently, returned to the near side and pulled that cord which seemed to cause the brake to be applied immediately. In the course of these movements he had shouted to the passengers to stay where they were as he was stopping the train, but a number of them were screaming and shouting and he doubted whether they had heard him. As soon as the train stopped he jumped out on the offside and came round the back of it to the near side where the passengers were getting out, to be told by an Italian that his wife had jumped from the train. The Wilshamstead signalman was at that time coming towards the train with an extinguisher, he took it from him and told him to return to the box to summons assistance, and went back to the car to use the extin-

guisher. He could not get it to work but took one from the guard and played it on the flames. Mr. Shepherd thought the flames had become less in the few minutes before the Fire Brigade arrived.

12. Mr. Shepherd had not noticed anything exceptional about the running of the car before the flames appeared but he thought that the engines had been running unusually fast and noisily when starting up from intermediate halts, and the car had seemed to drag.

13. The Italian whose wife jumped from the train to her death was *Lengthman A. Canzano*. He thought that he was travelling in the forward compartment, next to the guard's compartment. He could not say what happened in the confusion after the flames and smoke arose except that he lost sight of his little son and while he was looking for him his wife disappeared. Canzano spoke through an interpreter, though he had a little English.

14. *Guard I. E. Lewis* was in the compartment at the front of the last car. When he saw the smoke he rang the buzzer to stop the train, he then turned to the emergency brake handle but saw that the vacuum gauge was already at zero. As soon as the train stopped he jumped out to help passengers alight and then to use extinguishers on the fire. He heard a man call out that his wife had jumped from the train and had been killed. Lewis did not hear any unusual noise before he noticed the smoke, but he had heard a noise when starting from one of the previous stations as if one of the engines had stopped. He had spoken to the driver on the loudaphone but had been told that both engines on the rear car were working.

15. *Driver A. T. R. Buxton* said that the train had been running normally. He heard the fire bell just before Wilshamstead box and made a good service brake application. (The train stopped with its front 330 yards ahead of Wilshamstead box). As soon as the train stopped he took his equipment and went ahead to protect the opposite line. He was able to stop a train on the Up Fast line, and later conducted it past his train. Buxton did not remember having heard a single bell from the guard to stop, but confirmed the loudaphone conversation earlier on about a supposedly faulty engine. He said that in fact one engine had stopped when the guard spoke to him but it was not one under the rear car.

16. Neither Buxton nor *Driver P. G. T. Powell* who had been driving the set before Buxton took it over had noticed any defect, other than a thump when the torque converter locked in. This is a fairly common phenomenon, however, on these sets which drivers understand to happen when one drive locks in at a different moment from the other.

17. *Signalman G. A. Hughes* at Millbrook box saw the train pass at normal speed, and apparently in good order. His signals were at clear for it. About five minutes later the Wilshamstead signalman telephoned him to call the emergency services which he did at once. *Relief signalman A. G. Wallis* at Wilshamstead saw smoke coming from the rear of the train as it approached his signalbox and noted that it was slowing down. He said that the train eventually came to a stand about 50 yards ahead of his box, (in fact the rear coach stopped about 150 yards ahead) and he ran at once to the train with a fire extinguisher. He was told by Mr. Shepherd that someone had jumped from the train so he handed the extinguisher to him and ran to his box to arrange for the emergency services; he then returned to help at the scene of the fire. In his hurry he omitted to send the obstruction danger message for the opposite line though he put his signals to danger. He said that he asked the Millbrook signalman to call the emergency services as he knew that Millbrook box had a direct line to the Railway exchange at Bedford whereas his box was only on the omnibus circuit.

18. *Foreman W. H. Fensom* examined the train after the fire, before it was taken to Bedford. He checked that both communication cord valves in the last coach were open (these valves are near the roof on either side in the driver's cab), and he subsequently reset them and opened them by pulling the cord. He was satisfied that they worked properly without undue force being required.

19. *Mr. J. P. Marson*, the Diesel Depot Superintendent, Cricklewood said that the car which caught fire had come from Shops on 11th February after a programme repair and had since run about 45,300 miles. The No. 2 engine had been changed on 1st March and No. 2 torque converter on 7th May. Apparently neither cardan shaft had been changed. The last standard examination in the department had been carried out on 27th August and the car had thereafter run 4,450 miles in service. He added that torque converters on these sets had to be changed fairly frequently, as had the striking forks in the final drive which control the direction of movement of the car and which are power operated pneumatically throughout all cars in the train from the driving cabs.

Power Car transmission Investigation

20. The St. Pancras/Bedford diesel multiple units are used intensively and they have given good service on the whole but the fleet has been beset with failures of various kinds. The fastening of the engine to the underframe has required strengthening, the flange between the torque converter of the engine has opened out, the free wheel has jammed, the bearings in the final drive have worn, and the striking forks have broken. Detailed redesign has been carried out to strengthen all weaknesses but the fleet has still not been as reliable as was hoped. After this fire Mr. A. E. Robson the Chief Mechanical and Electrical Engineer, London Midland Region gave instructions for a comprehensive review to be made of the engine transmission as a whole to find out what was the originating cause of the breakdown and to find a remedy. An important clue was found in Cricklewood depot a short while after the fire when it was noticed that certain cardan shafts were slightly bent. A more detailed examination showed that a number of such shafts were out of true, and it seemed likely that they had become bent when the converter end was freed to change the torque converter, the final drive end of the shaft being left attached and the shaft being then lowered to a position where it was resting on the bogie headstock, about 18 ins. from the final

drive end. Working in cramped conditions in the pit under the car it would be easy to lose control of the heavy shaft and let it drop on to the frame thus bending it slightly. The out of balance forces thereafter set up by rotation of the bent shaft at about 1850 r.p.m. when running at full speed, would have been considerable and would have affected all parts of the transmission. A summary of the investigation prepared for Mr. Robson on the cause of this fire is at the Appendix. In view of the findings he arranged for all cardan shafts on the 60 power cars to be examined and those not perfect to be straightened and balanced at Derby Works. By 9th December this examination had been completed and 40 shafts had been found to be out of true and had been replaced Thereafter appropriate instructions were issued to ensure that all cardan shafts will be subject to an examination at regular intervals at Depots, and to specified tests after overhaul in Main Works.

Conclusion and Remarks

21. I have no doubt that the cause of the fire was as outlined in the report at the Appendix. Out of balance forces caused by a bent cardan shaft revolving at speed resulted in damage to other parts of the transmission and in the breakage of the shaft. The flailing ends of the broken shaft ruptured the fuel tanks and sparks ignited the vaporised fuel. It may well be that the initiating cause of the failure on this occasion is the one which has given rise to many of the previous troubles on this stock and that serviceability will be very much better in the future as a result of the measures now taken.

22. I do not think that there was any failure of the passenger communication cord to apply the brake. The onset is gradual and Mr. Shepherd's reactions would be very much speeded up in the stress of the emergency so that he might have thought the time longer than it really was between his first pulling the cord and the brake taking effect. The brake application arising from this action may have been the one he noted when he pulled the second cord.

23. I was glad to note the robust and fireproof construction of the floor of the car. The heat beneath it must have been intense for a short while but the floor covering inside the car was in no way affected.

I have the honour to be,

Sir,

Your obedient Servant,

W. P. REED,
Colonel.

The Secretary,
Ministry of Transport.

British Railways—London Midland Region
C.M. & E. Engineer's Department,
Nelson Street,
Derby. 21.12.64

FIRE ON 12.35 P.M. ST. PANCRAS TO BEDFORD, SATURDAY 10.10.64

CAR NO. 51591 M.B.S.

The cardan shaft fitted in the No. 2 position of Car No. 51591 was found to have a definite bend and deformation had occured at a point 18" from the final drive end, which coincided with the bogie headstock.

After a full investigation it can only be assumed that the initial damage to the tube was caused when the torque converter and final drive were changed in the Works in January 1964.

When the cardan shaft was being replaced following the above unit replacements, it is possible that the shaft tube was allowed to come into contact with the bogie headstock causing a slight dent.

Slight mal-alignment of the shaft resulting from denting could have caused out of balance forces which increased and eventually became excessive.

It was evident from examination of the stub shaft splines that the cardan shaft had been bent for some time as shown by metal pick-up on the top side at one end and bottom side at the other end.

Due to the resulting partial seizure of the splines an end load was imposed on the torque converter output flange securing nut, causing damage to the thread in the nut with resultant loosening of the torque converter flange to which was bolted the Hardy Spicer flange of the cardan shaft (splined end).

With the shafts revolving at approximately 1850 r.p.m. under these conditions, considerably out of balance forces were induced into both the cardan shaft and the torque converter output shaft attached to the free-wheel outer race, resulting in fracture of the cardan shaft and free-wheel outer race.

The flailing portion of cardan shaft still attached to the torque converter dislodged the safety loop and fixings; it then came adrift complete with torque converter output flange, securing nut and locking plates, and struck the sleepers as evidenced by marks found on same. This portion of shaft then damaged No. 1 fuel tank.

The force with which the shaft struck the sleepers caused the two set screws retaining one of the needle roller bearing assemblies of the Hardy Spicer coupling to come adrift.

The flailing of the portion of cardan shaft still attached to the final drive caused further denting and swaging of the tube due to contact with the bogie headstock and also holed No. 2 fuel tank.

The separation of the lower half of the torque converter housing from the engine flywheel is considered to be consequential, due to stresses set up by the aforementioned failures. There was no damage to the engine.

Examination of No. 2 final drive revealed that the striking fork (original design) had fractured and considerable damage to the dog teeth on both bevel wheels had occurred due to ratcheting, but there was no evidence that the drive had been reversed.

The ensuing fire was a result of the puncturing of the fuel tanks which allowed fuel oil to come into contact with the hot exhaust system, vapouring the fuel with resultant combustion.

The automatic fire system (Graviner) had operated over No. 2 engine but, of course, could not cover the whole fire area.

A full investigation regarding the marking of cardan shafts in the proximity of the bogie headstock has been carried out on a similar type of power car to car No. 51591 put in none of the tests outlined below could fouling of the cardan shaft be reproduced.

(1) Movement up traverser ramps in Derby C. & W. Works.

(2) 100% over-load tests with wheels worn down to minimum diameter.

(3) Vehicle taken round a 2.9 chain curve when it was found that the bogie bolster suspension bolts were fouling the friction blocks, restricting any further movement of the bogie, at which condition the cardan shaft was still $\frac{5}{8}$" clear of the bogie headstock at the narrowest point.

(4) With the vehicle bogies on different roads, until the conditions outlined in paragraph 3 were obtained, the cardan shaft tube was still $\frac{3}{8}$" clear of bogie headstock cut away.

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